Background

A vision to transform Singapore into an intelligent island has been formulated in the information technology master plan – IT2000, unveiled in August 1991. Spearheaded by the Infocomm Development Authority (IDA) of Singapore (the former National Computer Board (NCB)), the IT2000 plan entails visions of transforming Singapore into a global center for science and technology, a high value-added and competitive location for production and also a critical node in global networks of commerce, communication and information[1]. Construction and real estate have been recognized as one of the major economic sectors in which information technology (IT) could be exploited to enhance the performance and quality of the construction and real estate development processes and the competitiveness of the industry.

Construction and Real Estate NETwork (CORENET) is the flagship project conceived under the IT2000 master plan for the construction and real estate sector. It was officially launched during the BauCON Asia ’95 Conference in September 1995. This strategic project is a major IT initiative spearheaded by the Ministry of National Development. The Building and Construction Authority (BCA) (the former Construction Industry Development Board) is actively driving and promoting CORENET in collaboration with other public and private organizations and with the IT leadership provided by the IDA. CORENET is a comprehensive information network system made up of various sophisticated IT components and application packages. The system and its components will be progressively developed in phases.

After more than five years since its introduction, CORENET has undergone several phases of developments and updates. One-Stop Access to Construction Information Services (OACIS) and One Stop Submission Center (OSSC) are two important functions that have been made available in CORENET.

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Despite progress made in the development and implementation of CORENET, companies or professions in the real estate development and post-development facility management businesses are still relatively uncertain of the potential benefits they can reap from the system.

This paper aims to provide an overview of CORENET to set the background for further discussion. The concepts of CORENET and the key functions offered by the system are examined in detail in the following section. The impact brought about by CORENET and how it will affect or change the practices and processes of the construction and real estate industry in Singapore are then discussed. The concluding section highlights the prospects of CORENET.

**Concept and functions of CORENET**

**What is CORENET?**
CORENET is a comprehensive network system consisting of a series of IT systems and services that allows seamless and expedient communication and exchange of information between relevant government agencies and parties involved in the construction and real estate industry. IT systems in CORENET are designed and developed to integrate four major processes in a building project lifecycle: design, procurement, construction, and facilities management.

Information providers of CORENET consist mainly of the participating government agencies that include BCA, Housing and Development Board (HDB), Urban Redevelopment Authority (URA), Ministry of Law, Ministry of Environment (ENV), National Parks Board (Nparks), Public Utilities Board (PUB), Fire Safety Bureau (FSB) and other statutory boards and agencies. Independent inputs from professional bodies like Singapore Institute of Surveyors and Valuers (SISV), Singapore Institute of Architects (SIA), Real Estate Developer Association (REDA) and others also constitute an important part of the CORENET information system. Brief notes of all the participating organizations are given in the Appendix. Architects, engineers, property developers, quantity surveyors, valuers, property managers, contractors, property consultants and other parties directly or indirectly involved in the real estate development processes, are targeted to be the main users of this network.

**What can CORENET offer?**
Construction is an important economic activity that has contributed significantly to the transformation of the cityscape of Singapore. However, the industry has been prejudiced for its low technology, labour-intensive and low value-added process and activity. CORENET is thus initiated with the primarily objective of re-engineering operations and processes in the construction industry. It is hoped that, with the use of information technology (IT), a high level of efficiency, productivity and quality can be achieved in every segment of the development lifecycle of a real estate project.

Unlike a passive information repository system, CORENET is an interactive platform that is capable of providing a high level of automation and integration to many construction and development processes. Some key services offered by CORENET include:

1. **One-stop Access to Construction Information Services (OACIS).**
   Integrating IT systems that offer information for the complete life cycle of a building project, OACIS provides useful information for different stages of a development process at the convenience of a click of a computer button. The information services are organized into four major categories: design, submission, construction/procurement, and facilities management. Figure 1 summarizes the hotlinks to information services offered by the OACIS.

2. **Integrated Submission System (ISS).**
The ISS system consists of a series of IT tools specifically created to assist qualified persons to verify and check computer-generated plans. The main components of the ISS system include:
   - **One Stop Submission Center (OSSC).** OSSC is envisaged to be a centralized virtual government agency, which coordinates the submission of building project plans and documents for processing and approval by the respective regulatory agencies. It allows the users, who are qualified persons, to carry out a whole range of plan submission activities electronically, from submitting...
building plan and application, communicating and receiving approval notices, tracking the application status, to archiving submitted application documents and plans (Lim, 1999).

- **Integrated plan checking (IPC).** IPC aims to automate the plan checking process using cutting-edge computer aided design and drafting technologies incorporated with expert knowledge and artificial intelligence system. The IPC database that contains the most up-to-date regulatory requirements will automatically alert qualified persons or architects of any non-compliance of building plans at the design stage. Rectification to the design can then be made accordingly and instantly prior to the submission. This helps to cut down the time wastage by not having to resubmit plans to different regulatory agencies for further verification.

(3) **Collaborative design.** Collaborative design involves setting up an IT environment where architects, engineers and quantity surveyors (QSs) at different workplaces can carry out design activities as though they are physically working together. Products to be developed in the collaborative design platform will include integrated project Web site, 2D drafting regulations and digital building product models.

(4) **Integrated project management (IPM).** Like the collaborative design model, IPM creates a centralized repository system that stores and shares project management information electronically by clients, project managers, consultants.

**Figure 1 One-stop Access to Construction Information Services (OACIS)**

Source: Building & Construction Authority, Singapore (summarized by the author)
and contractors of a particular project. The standard formatting of the database improves the efficiency in the retrieval and entry of project data. The integrated project management system also provides a common platform that allows project team members to conduct meetings via remote conferencing. This enhances communication between the design team and contractors and shortens the time in the design and construction processes.

**Impact of CORENET on the Singapore construction industry**

Opportunities are indeed abundant for CORENET. Its potential, however, has not yet been fully exploited or utilized to improve the performance and productivity throughout the project lifecycle. First-mover competitive advantage can be attained, if developers can make better use of the system to fully integrate their operational functions both internally and externally. CORENET can serve as a catalyst to the so-called “IT-induced business reconfiguration”, as proposed by Venkatraman (1991), in the construction and real estate industry.

Business reconfiguration or reengineering is not a process of putting old wine into a new bottle. It involves “using the power of modern information technology to radically redesign our business processes in order to achieve dramatic improvements in their performance” (Hamel, 1990). Business reconfiguration may lead to a higher level of interrelatedness in the flow of activities within the organization, and also between the project teams and contractors who are involved in putting together the final products. Based on the proposed framework of Venkatraman (1991) (Figure 2), reengineering will take place in five different stages in an evolutionary process:

1. localized exploitation;
2. internal integration;
3. business process redesign;
4. business network redesign; and
5. business scope redefinition.

Stage one of the hierarchy involves the exploitation of IT to improve the operational efficiency of various business activities and functions. The widespread applications of word processor, spreadsheet and other job-

![Figure 2 Hierarchy of IT-induced reconfiguration](image)

**Figure 2** Hierarchy of IT-induced reconfiguration

<table>
<thead>
<tr>
<th>Degree of business transformation</th>
<th>Level 1: Localized exploitation</th>
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<tr>
<td>Level 2: Internal integration</td>
<td>Level 3: Business process redesign</td>
</tr>
<tr>
<td>Level 4: Business network redesign</td>
<td>Level 5: Business scope redefinition</td>
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**Range of potential benefits**

Source: Venkatraman (1991)

specifics IT programs like computer aided design (CAD) are examples of level one IT evolution actively pursued by many construction and real estate companies. The integration of internal IT systems via the common platform of local area networks (LANs) [3], and the sharing of a centralized database and knowledge-base by different departments and/or divisions are the second level process that has taken place in some real estate and construction companies.

The IT induced evolutions have so far been concentrated mainly at stages one and two of Venkatraman’s hierarchy. Cost-efficiency, operational effectiveness and also workflow connectivity within the organization are the immediate benefits arising from the IT changes at these two stages. Revolutions to the business practice, process and scope, which form the higher hierarchies of Venkatraman’s IT induced reconfiguration (1991), are not currently evident in the real estate and construction industry. CORENET initiative, however, signifies one giant leap ahead that will bring about industry-wide revolutions in the long run, which may take the forms of process redesign, network redesign and scope redefinition.

**The potential benefits of CORENET**

How will CORENET help to reengineer the process and redefine the scope of the real estate development business? What opportunities will CORENET offer to a whole range of real estate development activities commencing from the pre-investment feasibility analysis, the conceptualization, design and construction,
to the post-construction maintenance, management and disposal of the development? There are at least three major areas in which we feel CORENET will have a far-reaching impact on the way construction and development activities are carried out: (1) **Compression of time and process.**

The application of IT in the real estate industry has inevitably improved efficiency and productivity in many aspects of the process. However, the productivity and efficiency gain is not an exponential function of the investment in IT. A bottleneck will be encountered when diminishing marginal effects creep into the localized function and internal integration of the IT. In this situation, additional investments incurred in installing, for example, a higher random access memory (RAM) in a desktop machine would be redundant if the increased processor capability cannot be fully exploited to shorten the time involved in the design process. Collaborative or concurrent design arrangement via an integrated CORENET platform is, however, a creative way of breaking down the bottleneck of IT application in the design process. By allowing the architect and engineering team to work together on a project simultaneously at different locations, unproductive times involved in getting different parties to meet face-to-face and to resolve conflicts in the design process could be vastly reduced. Compression of time and process can be attained in the design process, if parties in the design team begin to utilize the collaborative design facilities offered by CORENET.

CORENET has an important role to play in reengineering the IT enabled workflows and activities in the real estate development process. Rigid longitudinal and sequential workflows are inefficient, and they should be broken down and compressed to minimize cost and time. In the standard corrective maintenance work routine, users of facilities will be the initiator of maintenance work requests, for example, lift breakdown, power supply cut-off, spalling concrete etc. The requests will be forwarded to the maintenance office and maintenance staff will then respond to the request by carrying out a site inspection. After maintenance requests have been verified, rectification works will be activated by issuing work order to term contractors. Time lags in the processes starting from maintenance request, inspection and verification of work requested to the issuance of work order are sources of delay in the corrective maintenance works. These processes can be compressed by linking the contractors and maintenance office via IT networks, so as to cut down the time lags and delays in corrective maintenance works.

OSSC is another CORENET facility, which is designed to cut down time wastage and improve workflow efficiency at the plan submission and approval stages. Backlogs and delays in plan checking and evaluation processes can be eased, if not fully eliminated, and plan approval times can also be significantly expedited when OSSC is fully implemented and operational. OSSC serves as a single contact point that links users' workstations to various government agencies involved in the plan checking and approving processes. It allows direct interaction between architects and the respective government agencies so that compliance of technical requirements imposed by various agencies and resolutions of design conflicts between the agencies and the architects can be carried out more expediently.

(2) **Knowledge-based networks.** The potential of CORENET should not be just limited to the role of information dissemination and sharing. It should move up the IT-enabled work reconfiguration hierarchy by adding value to its capability. Instead of merely publishing various market indices and macro level data of real estate and construction markets, it would be challenging to information providers to incorporate knowledge “interface” into the existing networks, such that more interactive applications and models that can be tailored to the needs of the users could be offered. Statistical models or quantitative tools that are able to add value to raw data and generate valuable outputs, which the real estate development and construction firms can use in their decision-making process, will be essential
for the creation of virtual “knowledge-based” networks. Constant review and update of the statistical results and projection generated by the knowledge-based model should also be carried out, so that the information always remains relevant and representative, especially information on housing inventory and stocks, price volatility etc.

Inventory management system equipped with just-in-time and artificial intelligence features is another facility that can be incorporated into CORENET. The inventory system will not only help to keep track of the level and utilization rate of various inventories, it may also encompass features that are sophisticated enough to automate inventory acquisition and stocking activities and also to optimize the inventory outflows and inflows in an efficient, yet cost-effective way. Electronic procurement, or E-procurement in short, is one of such industrial driven initiatives that uses the CORENET platform to encourage construction firms to move the traditional procurement practices on to an electronic medium.

Other knowledge features that are intended for CORENET include the feature-based CAD and the building plan (BP)-expert systems. In the planning approval phase, the feature-based CAD will automatically check and detect any non-compliance with stipulated regulations, whereas the BP-expert system will check for any technical irregularities with reference to the building regulations.

(3) New business model and opportunities. Two significant trends are predicted to take place in the real estate and construction industry, when more real estate construction and development activities and processes are seamlessly connected and integrated via CORENET. First, new business opportunities that involve a whole range of knowledge-based services, which help the information receivers or end-users to make sense out of the raw information, will emerge. Such value-added services may encompass data evaluation, statistical and technical analyses, performance benchmarking, and future demand forecasts. For information providers, more investment will have to be injected to improve the existing and/or to
develop a new and more sophisticated knowledge-based infrastructure, so as to meet the users’ growing expectation. Research and academic institutions are expected to play a more active role in sharing and putting their technological expertise into practice and application via research collaborations relating to CORENET. Toolboxes with different technical and knowledge contents can be installed or built into the CORENET system, which offer the end users a range of options for direct and selective access to “processed” and up-to-date market information. This will cut down the costs and time involved in the information search process. Moreover, the market will function more efficiently by making the information more transparent and, in the process, speculative activities can be eliminated or minimized. At the same time, unfair practices by users or firms, which ask exorbitant fees for privileged or proprietary information, will also be obstructed.

Second, the traditional real estate business model of selling “bricks and mortar” may be repositioned or revolutionized in a bold way. The typical development lifecycle activities commencing from design, procurement, contract administration, project management, defect warranty to rectification works, may be extended to include value enhancement and advisory services that involve providing expert advice on mortgage analysis, disposal and purchasing of existing and new properties, and also value enhancement management for the prospective investors. The chain of extended business activities contemplated for the new real estate business model could be offered via a virtual type of business setting. In a proposed one-stop virtual real estate corporation or firm, which is wired up with the networks of material suppliers, contractors, developers and financial institutions, investors and/or homebuyers could access and “window-shop” various professional real estate and construction services tailored to individual needs and expectations on the network. The “purchase” of the real estate services will be activated electronically, and pre-qualified, non-virtual companies will then
carry out the role of delivery and fulfilment of services.

The realization of the virtual corporation idea may appear to be remote at the current stage of the real estate industry, which is still not able to shed the image of the “brick and mortar” business. It is nevertheless not entirely unrealistic to imagine, one day, a situation where “bricks and mortar” can be customized via the cyberspace to meet the demand of individual users. The question of how fast this virtual corporation idea would be realized would largely be dependent on how confident the investors are in making use of such facilities in the virtual environment.

**Barriers to entry**
CORENET enhances the inter-relatedness of companies and government agencies involved in the real estate and construction industry and opens up new business opportunities for the companies. On the other hand, interconnectivity may also subject companies to some downside risks. There may be reservations and hesitation in some real estate companies on the potential advantages they can seize by being the first-movers. Four stumbling-blocks that may slow down the “absorption” of CORENET into the real estate and construction activities are identified. First, companies may like to protect their competitive advantages by withholding their proprietary information from the CORENET platform. Second, there are uncertainties with respect to the companies’ intellectual property rights on the information. Third, the incompatibility of the existing IT equipment and system of the users may also technically inhibit the ease of connectivity to the CORENET. The vulnerability to external intrusion when they are connected to the CORENET is also an important technical barrier to entry. Fourth, human resource and organization culture are also important factors that will determine success or failure in the adoption and implementation of CORENET.

**A driver of revolution in the real estate and construction industry**
CORENET, when it is fully implemented, is likely to have a significant and far-reaching impact on the real estate industry. The CORENET driven revolutions in the real estate and construction industry, which are more immediately anticipated, are examined in three separate stages:

1. **Pre-development evaluation stage.** A complete range of information services, like tender announcements, cost statistics on building materials, labour and machines, would be made available and updated regularly on CORENET to support the proposed electronic contract procurement method. Integrated cost estimation software may also be installed for project evaluation and cost estimation. Tendering exercises like bidding and awarding of contracts may also be conducted electronically via CORENET.

2. **Construction stage.** Through the project Web site and the electronic building product models, the developer will be able to concurrently monitor the work progresses of different contractors at different project sites. Changes to designs and variations in the project schedule and costs can also be detected and attended instantaneously because of more efficient interlinks of information and communication systems between different parties participating in development project.

3. **Post-development facility management stage.** An electronic building product model containing technical details of construction, mechanical and electrical services, coupled with comprehensive maintenance and operation manuals, can be made available electronically on CORENET. This electronic building product model will then be handed over to the building owner upon physical completion of the building. Technical details of the building structure and services will equip the building owner with information necessary in the planning of preventive and corrective maintenance programs, and also help him in the management of future expansion of space.

**Prospects of CORENET**
The success of a system is not solely dependent on the level of sophistication of the services offered and technology used in the system. It is the ease of assimilation and
integration of the system into the business operation and activities that matter. The objectives of CORENET to re-engineer business processes and to achieve a quantum leap in turnaround time, productivity and quality of the real estate and construction processes can be attained, if the internal infrastructure, organization culture and human resources of the real estate and construction companies are readily geared up to receive and apply the new technology. The IT readiness at the localized exploitation and the internal integration levels are important prerequisites for the real estate and construction companies, if they wish to tap into the potential of CORENET to revolutionize their business operations and practices.

In short, the success or failure of CORENET in reconfiguring the real estate development industry in Singapore is to a great extent dependent on:

- the degrees of “connectivity” of developer firms to Internet and intranet facilities;
- the corporate culture, attitude and literacy levels of staff towards IT; and
- the “drivers”, “barriers”, and benefits of exploiting Internet and intranet infrastructure by companies.

When it is fully implemented, CORENET is expected to have some revolutionary impact on the scope and the nature of the real estate development business in Singapore. We may observe a new form of competition and rivalry between parties involved in the real estate development industry, where the “winner takes all” type of mindset would be converted into one that emphasizes a win-win outcome via competition and collaboration. We might call this new business strategy a “Collabotition” – Collaboration and Competition.

Notes

1. A new five-year information and communication technology 21 plan – Infocomm 21 – has been conceptualized by the collective effort of various government agencies to build on the IT2000 vision of an “intelligent island”, that has largely become reality after nearly ten years of implementation.
2. The key CORENET services mentioned in the paper are by no means exhaustive. More details on the CORENET services are available electronically at http://www.bca.gov.sg/
3. Local area networks (LANs) are the communication networks used to connect various workstations and also the shared-distribution databases management and knowledge-based systems within a company.

References and further reading

# Appendix

| Table A1: Brief notes of government agencies and professional bodies participating in the CORENET project |
|---|---|
| **Government agencies/professional bodies** | **Roles and responsibilities** |
| **<Webpage links>** | |
| Ministry of National Development (MND) | MND is responsible for the physical development of Singapore, which includes land use, public housing, conservation, park development and others |
| [http://www.mnd.gov.sg/] | |
| Ministry of the Environment (ENV) | ENV provides and manages infrastructure for liquid, solid waste and storm water system. It also enforces high public health standards and implements pollution control measures |
| [http://www.env.gov.sg/] | |
| Building & Construction Authority (BCA) | BCA is the regulatory body for the building and construction industry. It aims to improve productivity and quality of construction works, raise skills and enforce compliance of safety and building standards in the industry |
| [http://www.bca.gov.sg/] | |
| InfoComm Development Authority of Singapore (IDA) | IDA is responsible for transforming Singapore into a global information and communication centre and world-wide digital hub. It plays a catalytic role in nurturing a healthy market and driving the information and communication technology industry in Singapore |
| [http://www.ida.gov.sg/] | |
| Urban Redevelopment Authority (URA) | URA is the national planning authority, which is entrusted with the crucial role of planning the nation’s future. It prepares long-range, as well as more detailed, local area plans for physical development and then co-ordinates and guides efforts to bring these plans to reality |
| [http://www.ura.gov.sg/] | |
| Housing Development Board (HDB) | Providing affordable homes of high quality is the primary mission of HDB. It plans, develops and upgrades housing estates to meet the needs of the population. It also manages HDB properties and formulates housing policies and programmes to foster cohesive communities |
| [http://www.hdb.gov.sg/] | |
| Land Transport Authority (LTA) | LTA spearheads improvements to the land transport system through integrated planning, development and management of land transport policies and infrastructure |
| National Park Board (NParks) | NParks plans, develops, maintains and regulates the parks and greenery provisions of Singapore to achieve an environment unique among major tropical nations |
| [http://www.nparks.gov.sg/] | |
| Public Utilities Board (PUB) | PUB is the national Water Authority and Regulator of the electricity and piped gas industries in Singapore. It is responsible for the development of the country’s water resources and operation and maintenance of the water supply system. It supplies water to the whole population of Singapore |
| Fire Safety Bureau (FSB) | FSB is the specialist department responsible for fire safety control in Singapore. The role of the FSB is to establish, implement and enforce a high standard of fire safety in buildings. It approves building plans and monitors compliance of fire safety regulations in existing buildings |
| [http://www.scdf.gov.sg/fs/fs.html] | |
| Singapore Institute of Architects (SIA) | SIA is the national organisation representing architects in Singapore. It serves to promote the interests of architects in Singapore and preserves professional integrity through the Professional Code of Conduct |
| [http://www.sia.org.sg/] | |
| Real Estate Developers’ Association of Singapore (REDAS) | REDAS is an association of property developers in Singapore. It protects and safeguards the legitimate interests of its members, and participates actively in making representations concerning various issues relating to businesses in real estate and public utilities |
| [http://www.redas.com/] | |
| Singapore Institute of Surveyors and Valuers (SISV) | SISV is the professional body representing the land surveyors, quantity surveyors, valuers, property managers, property consultants and real estate agents |
| [http://www.sisv.org.sg/] | |